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NAPS AS AN ALERTNESS MANAGEMENT STRATEGY

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Introduction. Today, 24-hour operations are necessary to meet the demands of our society and the requirements of our industrialized global economy. These around-the-clock demands pose unique physiological challenges for the humans who remain central to safe and productive operations. Optimal alertness and performance are critical factors that are increasingly challenged by unusual, extended, or changing work/rest schedules. Technological advancements and automated systems can exacerbate the challenges faced by the human factor in these environments.

Shift work, transportation demands, and continuous operations engender sleep loss and circadian disruption. Both of these physiological factors can lead to increased sleepiness, decreased performance, and a reduced margin of safety. These factors can increase vulnerability to incidents and accidents in operational settings. The consequences can have both societal effects (e.g., major destructive accidents such as Three Mile Island, Exxon Valdez, Bhopal) and personal effects (e.g., an accident driving home after a night shift).

Alertness management strategies. Alertness management strategies can minimize the adverse effects of sleep loss and circadian disruption and to promote optimal alertness and performance in operational settings. Clearly, no single strategy will fully address the sleepiness and performance decrements engendered by 24-hour operational demands. Sleep and circadian physiology are complex, individuals are different, the task demands of settings are different, and schedules are extremely diverse; therefore, it is naive to believe that a single strategy can address all of these considerations. It is more useful to consider the range of strategies available to optimize alertness and performance in operational settings. A combination of strategies may provide the greatest potential to meet these physiological challenges.

Alertness management strategies can be categorized as preventive and operational strategies (ref. 1). Preventive strategies, which are used before a duty or shift period, can address the underlying physiological mechanisms associated with sleep and circadian factors. For example, some preventive strategies might facilitate circadian adaptation prior to an altered work/rest schedule. These might include the use of bright light or melatonin to promote circadian adaptation before beginning a series of night shifts. Other preventive strategies might promote sleep quantity and quality before a period of sleep loss or disruption. Operational strategies are used during a duty or shift period to maintain performance and alertness. These strategies might include strategic caffeine consumption, physical activity, or social interaction. These strategies are intended to maintain alertness and performance during an operational requirement but may have no, or minimal, effect on underlying physiological mechanisms (i.e., sleep loss and circadian disruption).

Naps as an alertness management strategy. Naps are a useful strategy that can be used in both a preventive and an operational manner. As a preventive strategy, naps can be used prophylactically to maintain alertness and performance during a subsequent period of prolonged wakefulness (refs. 2, 3). A nap can also be used to reduce the hours of continuous wakefulness before a shift or duty period and the total hours awake at the end of the subsequent work period. For example, a shift worker who awakens at 0800, reports to a 2300 shift, and finishes the shift at 0700, is returning home in the 24th hour of wakefulness. An afternoon nap in the 1500-1700 window of sleepiness will decrease the number of continuous hours of wakefulness to 14 (i.e., 1700-0700).

Naps also can be used as an effective operational strategy. Naps used to interrupt sustained periods of wakefulness during a continuous operation can help to maintain the level of

performance and alertness (refs. 4, 5). Studies have examined different nap lengths and durations of subsequent wakefulness. A nap can be used as an alertness management technique during operations, such as in shift work and transportation environments.

The following study is described to emphasize two points. First, it demonstrates the effectiveness of a planned nap in maintaining alertness and performance in a mode of transportation. Second, empirical evaluation of potential alertness management strategies in actual operational settings will be critical to their successful implementation. Long-haul flight operations can involve multiple time-zone changes and long duty periods, and can engender sleep loss and circadian disruption. Anecdotal reports, logbook studies, and confidential incident reports to the National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System clearly demonstrate that as a consequence, flight crews can experience spontaneous and unplanned sleep episodes. A NASA/Federal Aviation Administration (FAA) study examined the effectiveness of a planned in-flight nap to maintain performance and alertness in nonaugmented three-person long-haul flight operations (ref. 6).

This study involved three-person, 747-200 aircraft flying regularly scheduled transpacific flights. The trip schedule involved 8 flight legs in 12 days. Each flight was about 9 hours in duration with an approximately 25-hour layover between flights. The volunteer flight crewmembers were randomly divided into two groups: Rest Group and No-Rest Group. Pilots in the Rest Group were provided a 40-minute, planned, in-flight nap opportunity during cruise over water. One pilot rested while the other two crewmembers maintained the flight. The nap opportunity was spent in the cockpit seat. The No-Rest Group had a 40-minute control period identified during cruise, during which they were instructed to maintain their usual flight activities. Both groups were evaluated with the same measures. Prior to, during, and after the trip schedule, flight crewmembers completed a daily logbook and wore an actigraph to estimate 24-hour rest/activity patterns. Two NASA researchers accompanied the crews during the four middle legs of the trip schedule for intensive monitoring. This involved continuous physiological monitoring of brain and eye activity and vigilance performance during flight.

On 93% of the nap opportunities, Rest Group crewmembers were able to sleep. They fell asleep in about 6 minutes and slept for about 26 minutes. To determine the effects of this brief nap, subsequent performance and physiological sleepiness was compared between groups. The No-Rest Group demonstrated the expected performance profile. Their performance was reduced on night flights compared to days, at the ends of flights compared to beginnings, and after multiple flight legs. The Rest Group, however, maintained consistent performance night and day, at the end of flights, and after multiple flight legs. Physiological sleepiness was examined by analyzing changes in brain electrical activity and eye movements during the last 90 minutes of flight, through descent and landing. Microevents associated with physiological sleepiness occurred in the No-Rest Group at a rate twice that of the Rest Group. The brief, planned, in-flight nap obtained by the Rest Group was associated with better subsequent performance and alertness compared to the No-Rest Group. Specific procedural and safety guidelines were utilized in the study to facilitate operational implementation. Partially as a result of this study, the FAA convened an aviation industry/government working group to draft advisory material to sanction controlled rest on the flight deck. This activity has now been upgraded to a planned regulation.

This study also emphasizes the need for empirical evaluation of potential alertness management strategies in operational settings. While anecdotal reports suggest that in-flight rest is used to maintain alertness and performance by flight crews, it is not currently sanctioned under Federal Aviation Regulations. It was critical to provide empirical data obtained during usual operations before regulatory action would be considered. Later, this issue will be discussed further as it pertains to implementation of strategies.

Potential negative effects of naps. There are two potential negative effects of naps that should be considered prior to operational use. The first is sleep inertia, the grogginess, disorientation, and sleepiness that can accompany awakening from deep sleep. Estimates on

the duration of sleep inertia effects vary from a few minutes to 35 minutes, though most negative residual effects appear to dissipate in about 10-15 minutes (ref. 7). Sleep inertia is affected by a variety of factors (duration of deep sleep, circadian time of nap, etc.) and therefore, specific predictions of its duration or severity are difficult. Sleep inertia is an important consideration when naps are used in an operational setting. In the in-flight nap study, a 20-minute period was allowed after awakening from the nap to examine potential inertia effects. This factor should be considered if an operator is likely to have a nap interrupted by an emergency requiring quick response with a high level of performance. However, this factor must be judged in relation to the potential benefits of improved alertness and performance following a nap.

A second potential negative consequence of naps is the effect on subsequent sleep periods. A long nap, at certain times of the day, can disrupt the quantity and quality of later sleep periods (ref. 8). While the nap can improve waking alertness and performance, it might increase subsequent sleep loss by disrupting a later sleep period. The disturbance could affect both the duration of the sleep period and its infrastructure.

No alertness management strategy will address all of the sleepiness and performance decrements associated with operational sleep loss and circadian disruption. It is also clear that each strategy will present both positive and potentially negative consequences that must be weighed prior to implementation. This reinforces the idea that combining strategies provides the best way to optimize operational performance and alertness.

Implementation. Various factors should be considered before implementing naps or other alertness management strategies in real-world operational settings. 1) An identifiable benefit: an alertness management strategy should provide a clear and identifiable benefit to the human operator and the operational environment (e.g., increased safety margin). It should minimize some adverse consequence or promote a particular positive outcome. 2) Opportunity: an appropriate opportunity for implementation should be identified. In some operational circumstances it may not be appropriate to consider a certain strategy (e.g., napping during a shift with high work demand or potential for emergency). 3) Corporate climate/culture: some strategies may be explicitly or implicitly supported, while others are actively suppressed. 4) Operational demands: the specific work demands and circumstances of a particular work environment may exclude some potential strategies. 5) Safeguards: alertness management strategies are intended to promote safety and productivity. Specific safeguards should be employed to ensure that strategies do not negatively affect the safety margin.

Other considerations. As attention to issues of work hours, sleepiness, and accidents increases, more approaches to address the issues will emerge. Therefore, it will be critical that empirical evaluations be used to demonstrate a quantifiable positive effect of proposed alertness management strategies. Empirical data will support the implementation of approaches that show a worthwhile effect and will expose ineffectual strategies. An important aspect of these evaluations is a demonstration of effectiveness in actual operational settings. This challenges researchers to take significant and provocative laboratory findings and translate them to the complexity of real-world demands. The premature application of strategies that are eventually determined to be ineffective can create a backlash that will impede the implementation of future approaches.

Combined strategies should be evaluated to determine the potential emergent effects of combination. For example, a comprehensive alertness management approach might utilize bright light or melatonin to facilitate circadian adaptation, strategic caffeine consumption during a window of circadian sleepiness, and a nap. Reliance on a single strategy may be less effective than combining approaches. Guidelines for implementing strategies in a particular environment should be developed and clearly stated.

Defining 'safety' and establishing what constitutes a 'significant performance decrement' are extremely difficult but important tasks. These delimitations are essential to determining the effects of work hours, sleepiness, and performance degradation on operational incidents and

accidents. In turn, evaluating the effectiveness of alertness strategies in attenuating these effects relies on the quantitative definition and assessment of the effects. Clearly, these can change with the specifics of a work setting, but this area remains difficult to quantify.

Finally, education and training programs provide crucial support to all of these activities (e.g., ref. 9). Individuals involved in all aspects of 24-hour operations must be informed of the factors that pose challenges to human physiology. This includes understanding potential strategies to minimize adverse effects and to promote optimal alertness and performance during operations. This information should be understood by operators, schedulers, regulatory agencies, accident investigation personnel, and others.

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